An Overview of Portland Harbor Ecological Risk Assessment Process and Screening Level Results

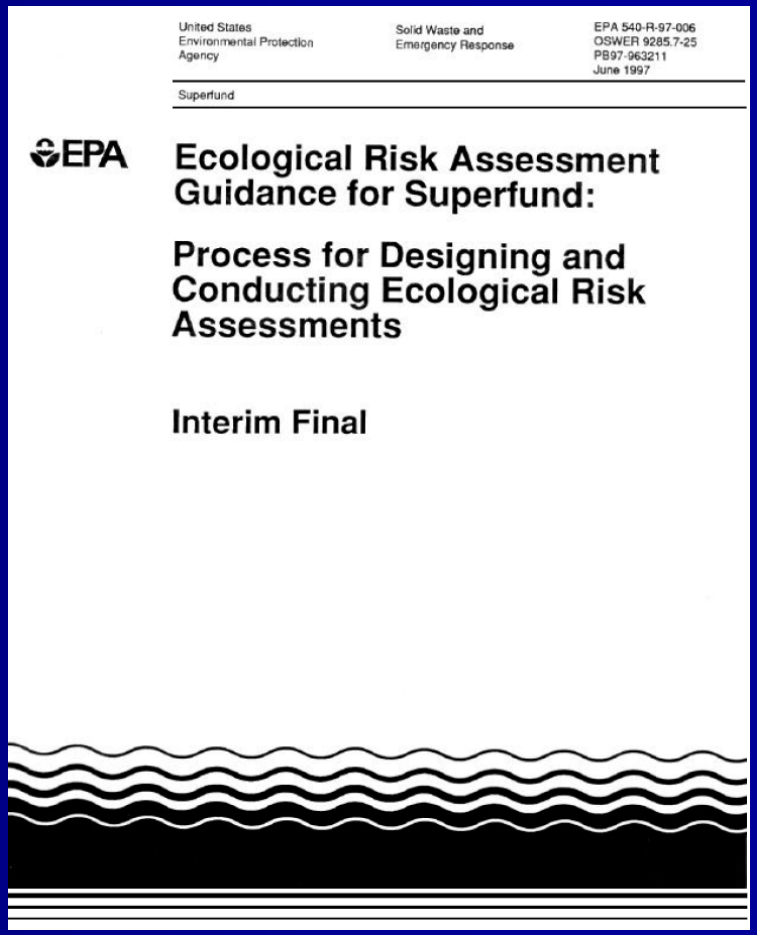
For the Portland Harbor Community Advisory Group

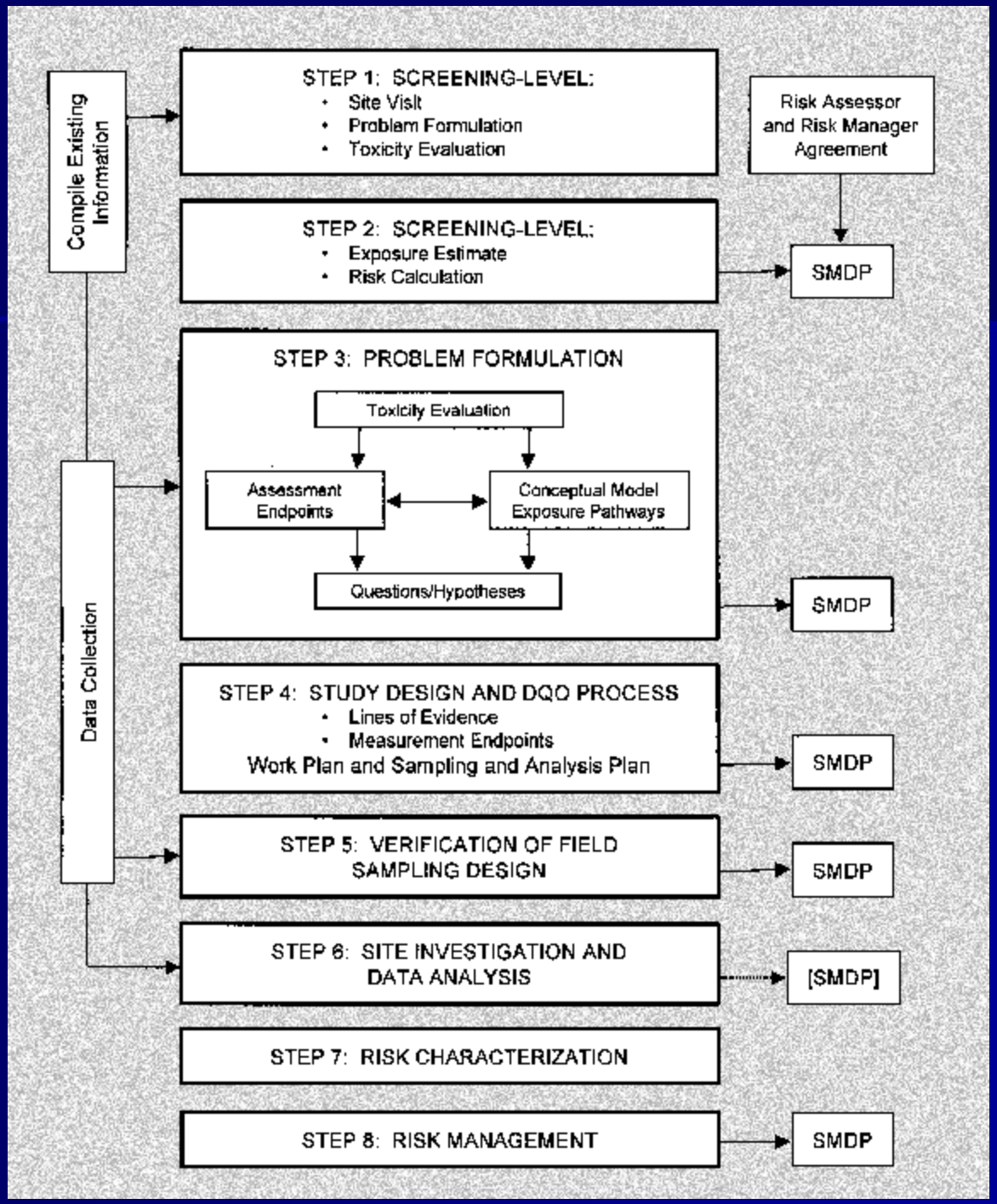
USEPA Region 10

April 8, 2009

For the Portland Harbor Ecological Risk Assessment Process, EPA Follows:

- Published in 1997
- Intended to make risk assessments site-specific, defensible and appropriately scaled
- Established 8-step EcoRA process
- Specific to Superfund program and consistent with general EPA guidance




Compile Existing Information
STEP 1: SCREENING-LEVEL:
• Site Visit
• Problem Formulation
• Toxicity Evaluation
Risk Assessor and Risk Manager Agreement
STEP 2: SCREENING-LEVEL:
• Exposure Estimate
• Risk Calculation
SMDP
STEP 3: PROBLEM FORMULATION
Toxicity Evaluation
Assessment Endpoints
Conceptual Model Exposure Pathways
Questions/Hypotheses
SMDP
Data Collection
STEP 4: STUDY DESIGN AND DQO PROCESS
• Lines of Evidence
• Measurement Endpoints
Work Plan and Sampling and Analysis Plan
SMDP
STEP 5: VERIFICATION OF FIELD SAMPLING DESIGN
SMDP
STEP 6: SITE INVESTIGATION AND DATA ANALYSIS
[SMDP]
STEP 7: RISK CHARACTERIZATION
STEP 8: RISK MANAGEMENT
SMDP

Key Characteristics of a Sound Ecological Risk Assessment

- Provides clear endpoints and rigorous technical analyses to support decisions
- Characterizes uncertainty in scientific information
- Facilitates a focused dialogue among scientists, decision makers, and the general public
- Maintains separation between risk assessment (scientific evaluation of data and models) and risk management (making decisions concerning risk)

EPA Ecological Risk Assessment Guidance Describes a Process, not a Recipe

- Data, methods, and models are problem and site specific
- The objective is to provide timely, scientifically-based technical advice to decision makers and the public
- Risk assessment may be either qualitative or quantitative

Key terms:

- **Assessment endpoint** – an explicit expression of the environmental value that is to be protected

- **Measurement endpoint** – A measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint. Can include measures of effect and/or measures of exposure

National Goal of Superfund is to Select Remedies Protective of Human Health and the Environment

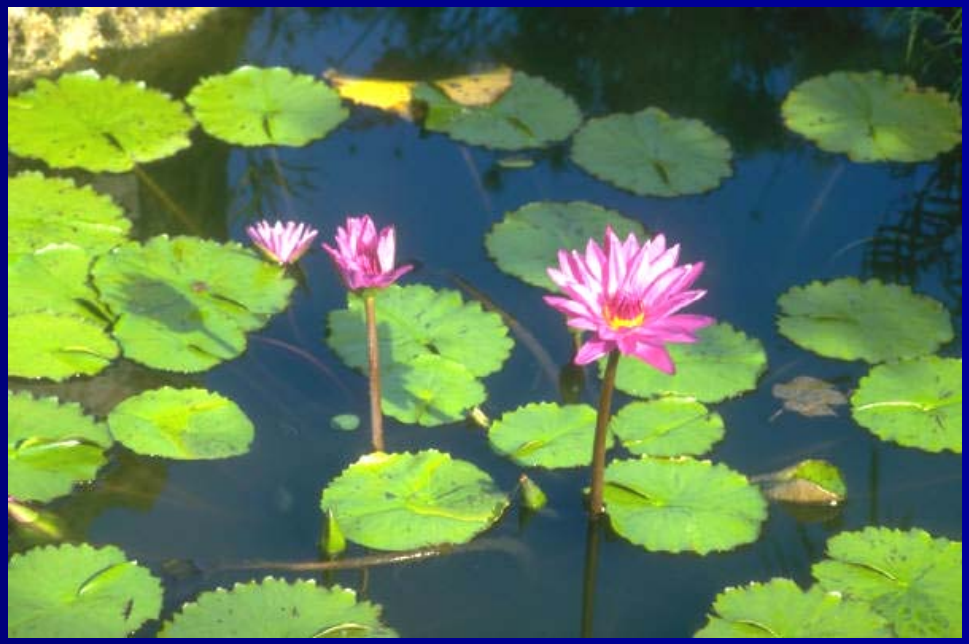
- ***Environment:*** **As defined by section 101(8) of CERCLA, environment means** ***"(A) the navigable waters, the waters of the contiguous zone, and the ocean waters of which the natural resources are under the exclusive management authority of the United States under the Magnuson Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.); and (B) any other surface water, ground water, drinking water supply, land surface or subsurface strata, or ambient air within the United States or under the jurisdiction of the United States."***

Screening Level Assessment and Measurement Endpoints

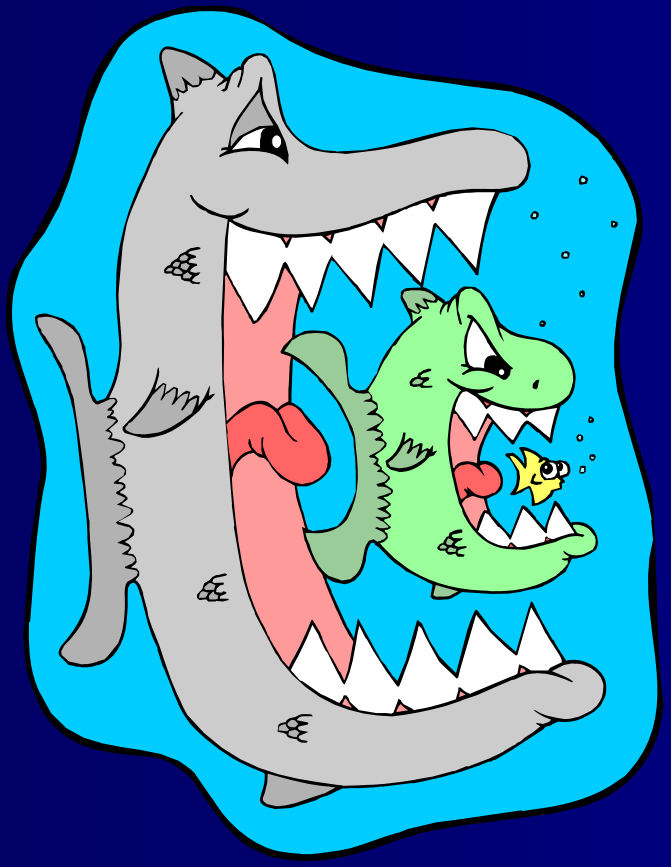
- Screening level assessment endpoints are any adverse ecological effects on ecological receptors (plant and animal populations, communities, habitats and sensitive environments)
  - Often expressed in terms of survival, reproduction and growth
- Screening level measurement endpoints are comparisons of media concentrations (or ingested doses) to conservative screening level benchmarks. Often non-site or species specific.

Aquatic Plants

Direct contact, root absorption



Aquatic Animals



Direct contact or ingestion

Aquatic Dependent Wildlife

Ingestion, inhalation, and dermal absorption

Pop Quiz: Is this an example of ingestion or inhalation?

Step 1: Preliminary Ecological Effects Evaluation

- Toxicity profiles: brief explanation of adverse effects
- Screening ecotox values or benchmarks
  - Screening = conservative
  - NOAEL (preferable for screening EcoRA) vs LOAEL
  - NOAEL's not available for many media-chemical combinations
- Screening values ≠ ARAR's

Step 2: Preliminary Exposure Estimate and Risk Calculation

Exposure generally occurs in two ways:

1. Environmental concentration in soil, sediment, surface water, air, or bioaccumulated in tissues of receptor.
2. Concentration in food: measured or modeled

Screening Level Risk Calculation

$$HQ = \frac{EDI}{NOAEL} \quad \text{or} \quad HQ = \frac{EEC}{TB}$$

Where:

HQ = hazard quotient

EDI = estimated daily intake

EEC = estimated environmental concentration*

NOAEL = no observed adverse effects level

TB (toxicity benchmark) = effect measure in environmental media

* For Portland Harbor SLERA, EEC is maximum detected concentration

Hazard Quotients

If…	Then…
HQ ≥ 1.0	Adverse effect likely, contaminant of potential ecological concern, forwarded to BERA
HQ < 1.0	Contaminant alone not likely to cause adverse effect, but interpret based on availability of information for other chemicals with the same mechanism of toxic action

Portland Harbor Screening Level Ecological Risk Assessment (SLERA) Process

- 2004 – Programmatic Work Plan, basis for subsequent sampling and monitoring studies
- February 2007 – Round 2 data report from LWG to EPA, contained initial screen based on samples collected from Rounds 1 and 2
- December 2007 – EPA prepared standalone SLERA, our review and summary of screen in the Round 2 report
- February 2008 – EPA sent draft problem formulation and analysis plan for baseline ecological risk assessment to LWG
- Summer 2009 – LWG to submit BERA to EPA for review

Conclusions of LWG's Round 2 Screen and EPA SLERA

- There are many ecological receptors potentially at risk from elevated contaminant levels.
  - A result of multiple chemicals in sediment, surface water, transition zone water, aquatic biota tissues, and diets of aquatic biota and aquatic-dependent wildlife
- EPA and LWG in close agreement on list of chemicals potentially posing unacceptable risk and receptors at risk

SLERA Results

- Chemicals whose maximum detected concentration in sediment, surface and transition zone water, tissue had HQ ≥ 1 forwarded to baseline ecological risk assessment (BERA)

- Results presented here are maximum hazard quotients (i.e. the worst case) from the EPA SLERA

SLERA Conclusions - Sediment

- 66 sediment chemicals had measured HQ ≥ 1.0
  - Metals - 11
  - Polycyclic aromatic hydrocarbons (PAH) – 19
  - Insecticides – 12
  - PCBs
  - Semivolatile organics – 18
  - Volatile organics – 2
  - Dioxins/furans

SLERA Conclusions – Sediment Contaminants with Largest Hazard Quotients

- Total PAH maximum HQ = 38,775
- Total DDX maximum HQ = 3063
- Trichloroethylene maximum HQ = 905
- Total PCBs maximum HQ = 803
- bis(2-ethylhexyl) phthalate maximum HQ = 483

SLERA Conclusions – Surface Water

- **10 chemicals exceeded screening level benchmarks**
  - **Zinc (max. HQ = 1.2)**
  - **Benzo(a)anthracene (max. HQ = 4.1) and benzo(a)pyrene (max. HQ = 11)**
  - **4-chloro-3-methylphenol (max. HQ = 1.1)**
  - **Total PCB (max. HQ = 1.2)**
  - **4 individual DDX compounds (max. HQ = 20 for sum of all DDX compounds)**

SLERA Conclusions – Transition Zone Water

53 chemicals exceeded screening level benchmarks

- 8 metals (max. HQ range = 1.3 for Cu to 1100 for Ba)
- 16 PAHs (max. HQ range = 13 for dibenz(a,h)anthracene to 2700 for benzo(a)pyrene
- 3 SVOCs (max. HQ range = 2.2 for dibenzofuran to 46 for 1,2-dichlorobenzene
- 6 insecticides (various DDX compounds, max. HQ = 3050)
- 2 herbicides (Dalapon (max. HQ = 1.2), Silvex (max. HQ = 4.4)
- 16 VOCs (max. HQ range 1.1 for vinyl chloride to 870 for carbon disulfide)
- Cyanide (max. HQ = 4423)
- Perchlorate (max. HQ = 9833)

SLERA Conclusions – Aquatic-Dependent Wildlife

- Ingested dose risks more complex to estimate, much work being done in BERA
- Spotted sandpiper may be at risk from more chemicals than any other wildlife receptor
- HQ > 100 for dioxins/furans to spotted sandpiper and mink, total PCBs for mink (max. HQ = 178) and river otter
- Lead, PAHs also possible risk drivers to sandpiper from beach sediments
- Maximum DDT HQ is 26 for hooded merganser
- Most metal, phthalate, remaining insecticide HQs <10 for all wildlife receptors

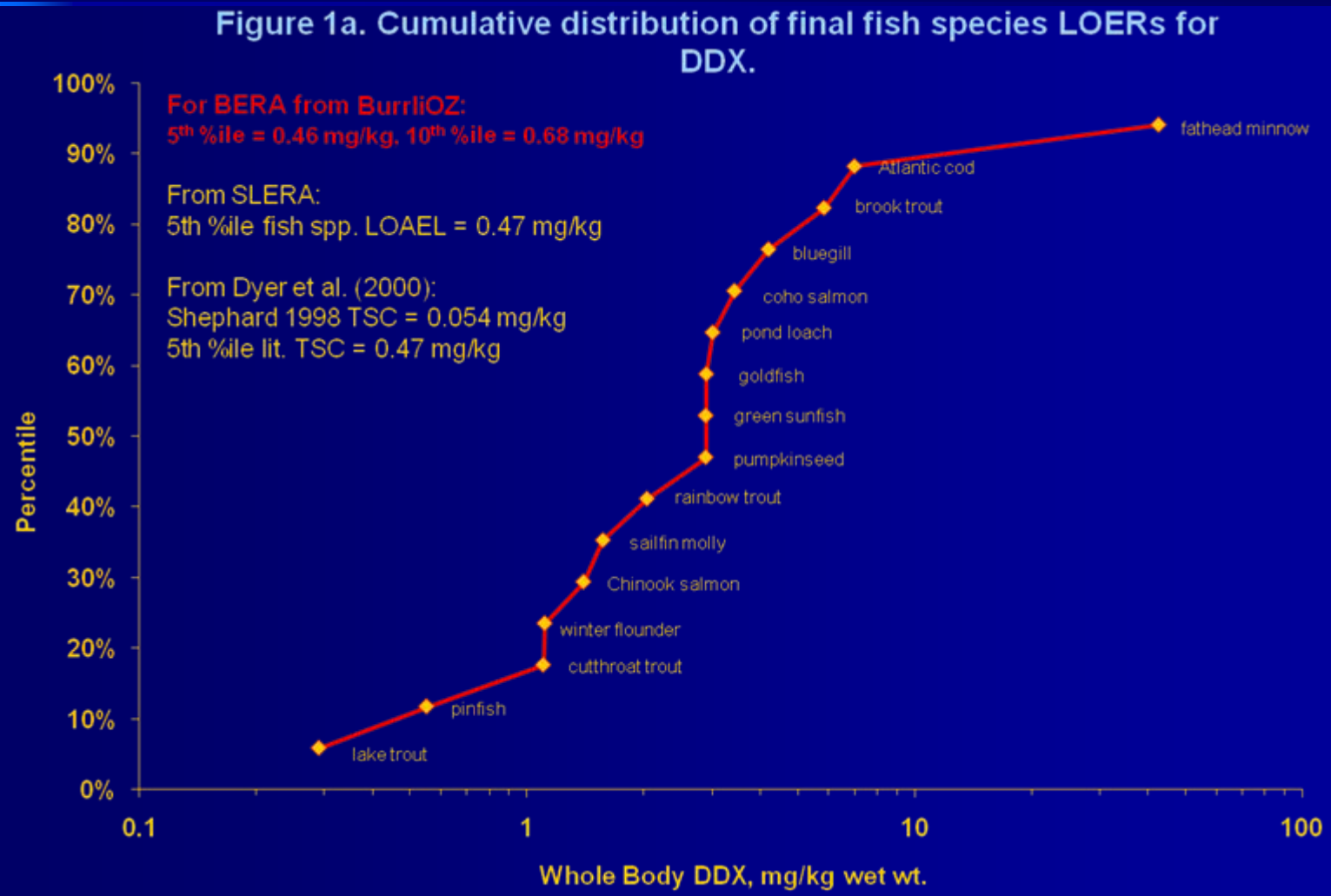
SLERA Conclusions – Aquatic Biota Tissues

- **19 chemicals exceeded screening level benchmarks**
  - 8 metals (max. HQ range between Cr HQ = 1.0 in largescale sucker and Cu HQ = 6.5 in *Lumbriculus variegatus*)
  - Tributyltin (max. HQ = 34 in *Lumbriculus*)
  - Total PCB (max. HQ = 6.9 in smallmouth bass)
  - 4,4'-DDD (max. HQ = 20 in *Lumbriculus*)
  - Total DDX (max. HQ = 11 in sculpins)
  - 3 phthalates (max. HQ = 223 for bis(2-ethylhexyl) phthalate in smallmouth bass)
  - Hexachlorobutadiene, β-HCH and δ-HCH all had max. HQ values ≤ 2.0 in sculpins

SLERA Conclusions – Aquatic Biota Tissues

- None of the 19 chemicals posing unacceptable risks to aquatic biota found in all species analyzed
- None of the tested aquatic species contained all 19 chemicals at concentrations exceeding screening level benchmarks
- Risk evaluation of contaminants in aquatic species a major emphasis of the human health risk assessment, but a relatively new development in ecological risk assessment

Example of Fish Tissue TRV Derivation for BERA (not a Portland Harbor example)

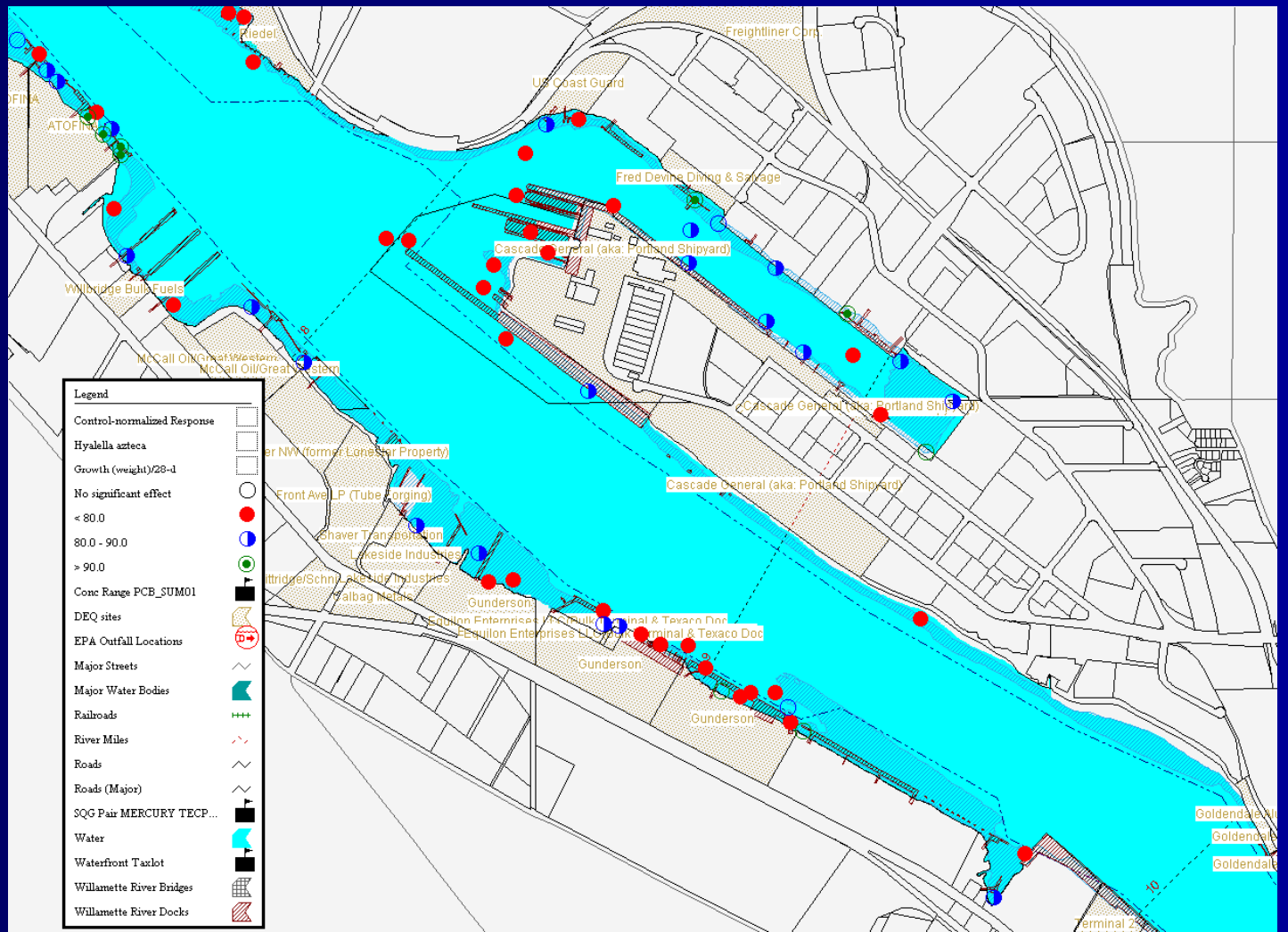


Sediment Toxicity Testing

- Measured sediment toxicity to two benthic invertebrate species using two different tests/species in 230+ sediment samples from Rounds 1 and 2
  - *Chironomus decorus* (formerly *C. tentans*) survival
  - *Chironomus decorus* biomass
  - *Hyalella azteca* survival
  - *Hyalella azteca* biomass

- One way to handle toxicity of mixtures in the EcoRA, chemicals for which EcoRA tissue TRVs cannot be derived (e.g. PAHs), or where no specific chemical(s) stand out as risk drivers

Example of Toxicity Test Results



Scientific Management Decision Point

A point during the risk assessment process when the risk assessor communicates results of the assessment at that stage to a risk manager. At this point the risk manager determines whether the information is sufficient to arrive at a decision regarding risk management strategies and/or the need for additional information to characterize risk.

Possible Results of Screening Level Ecological Risk Assessment

- One can potentially eliminate from analysis in BERA
  - Particular chemicals or classes of chemicals
  - Particular media as sources of contaminant exposure
  - Particular ecological receptors as credible assessment endpoints
  - Ecological risks as basis for remedial action
- Decide to move forward with removal action
- Continue to Step 3 (i.e. perform a baseline ecological risk assessment)

What Gets Passed Through to the BERA?

- Chemicals in media that exceed screening level benchmarks (even if only one sample)
- Media / receptors without quantitative data, other data gaps that need to be filled
- Detected chemicals without toxicity benchmarks
- Detected chemicals whose detection limits exceed toxicity benchmarks

Portland Harbor EcoRA Process: Baseline Ecological Risk Assessment (BERA)

1. Screening site visit, problem formulation and screening toxicity evaluation
2. Screening exposure estimate and screening risk calculation
3. **Problem Formulation**
4. **Study Design & DQOs**
5. **Sampling plan verification**
6. **Site investigation**
7. **Risk Characterization**
8. Risk Management

Problem Formulation is:

- ***…the first phase of ecological risk assessment and establishes the goals, breadth, and focus of the assessment (EPA 1992)***
  - **Goals defined by statute, regulation, public scoping, or other policy considerations**
  - **Breadth defined by the initial data review**
  - **Focus defined by assessment endpoints**
- **An essential planning activity**
  - **defines data collection needs and assessment approach**
- **A major cause of failure in risk assessments**
  - **poor planning ⇒ poor data ⇒ poor decisions**

After the Problem formulation step there is a decision point

- Agreement on four points:
  - Assessment endpoints
  - Exposure pathways
  - Risk questions
  - Conceptual site model
- Without agreement on the above between risk assessors, risk managers, and other parties, cannot select measurement endpoints

Portland Harbor BERA
13 Assessment Endpoints
Survival, growth and reproduction of:

1. Aquatic plants
2. Benthic macroinvertebrates
3. Bivalves
4. Decapods
5. Invertivorous fish
6. Omnivorous fish
7. Piscivorous fish
8. Detritivorous fish
9. Amphibians
10. Piscivorous birds
11. Omnivorous birds
12. Invertivorous birds
13. Aquatic-dependent mammals

Criteria that any measurement endpoint should meet

- Ecological relevance
- Unambiguous operational definition
- Accessibility to prediction and measurement
- Susceptibility to hazardous substances

Another Scientific Management Decision Point

- Risk assessors and risk managers agree on:
  - Measurement endpoints
  - Site investigation methods
  - Data reduction and interpretation techniques
- Move to next steps

Portland Harbor BERA Measurement Endpoints

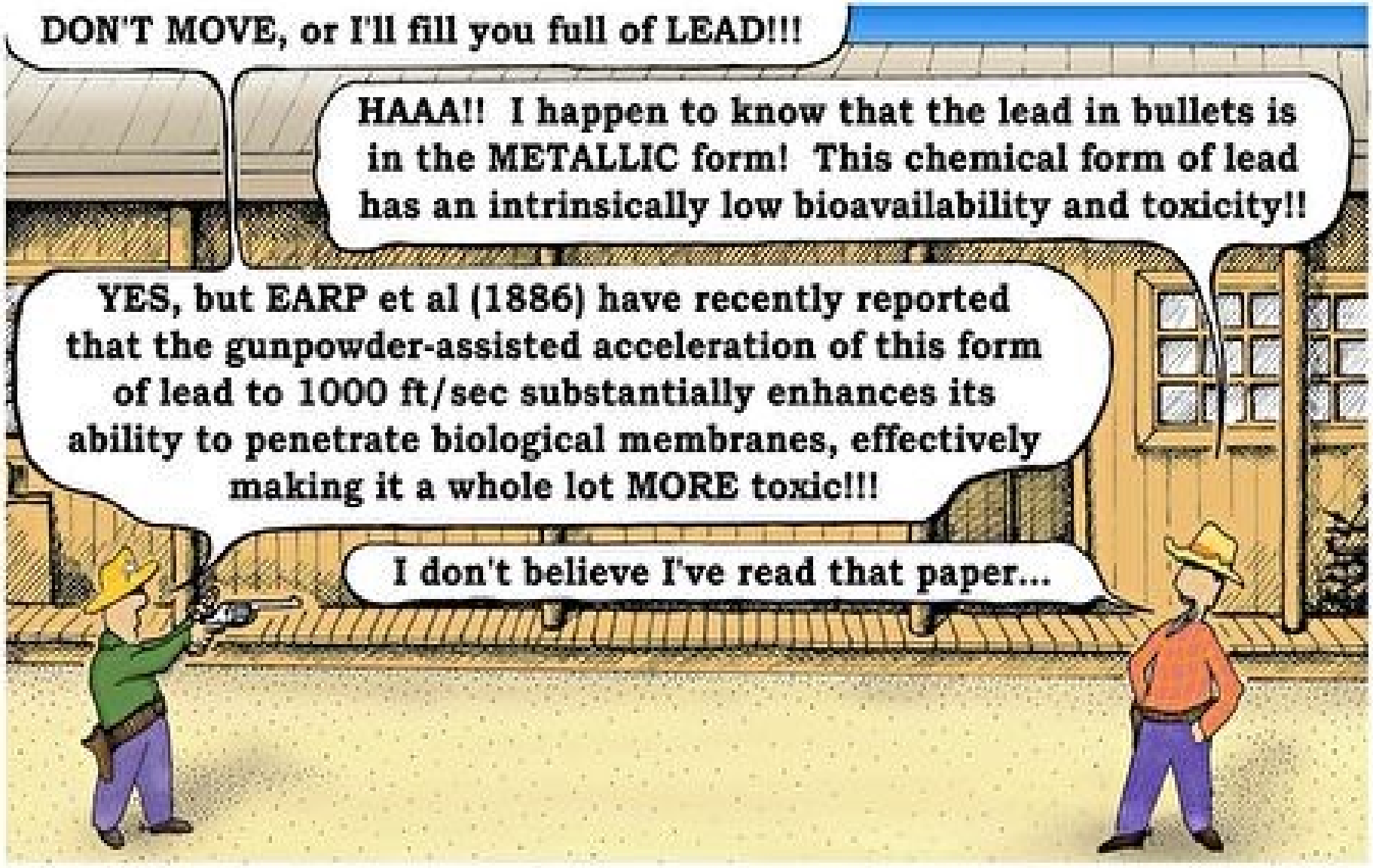
- We have 31 measurement endpoints
- The 31 measurement endpoints have a combined 49 lines of evidence

End Products of Ecological Risk Assessment

- Which ecological receptors are at risk?
- What chemicals pose unacceptable risks?
- Where within the site are areas of unacceptable risk found?
- Uncertainties in the risk assessment
- Recommend cleanup numbers protective of ecological receptors
  - Often described as a threshold for effects on the assessment endpoint as a range between concentrations posing no ecological risk and the lowest contaminant concentrations identified as likely to produce adverse ecological effects

Risk Management for Portland Harbor – Last Step of the BERA

- Done by risk managers (project managers), not risk assessors (I don't get to pick the final cleanup values or the remedy)
- Evaluates several factors in addition to ecological risks (e.g. human health risks)
- Risk management decision finalized, described and justified in Record of Decision for the site



ENVIRONMENTAL SCIENTISTS IN THE WILD WEST